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Technical Note 130
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SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

40. BIZERTE

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ABSTRACT

This handbook for the port of Bizerte, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

ACKNOWLEDGMENTS

The support of the sponsors - Naval Oceanography Command, Stennis Space Center, MS: and Fleet Numerical Oceanography Center, Monterey, CA (Program Element O&M,N) - is gratefully acknowledged.

CONTENTS

FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Atmospheric Directorate, Naval Oceanographic and Atmospheric Laboratory (NOARL), Monterey, to create products for direct application to Fleet Operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to NOARL, Monterey for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review. Computerized versions of these port guides are available for those ports with an asterisk (*). Contact the Atmospheric Directorate, NOARL, Monterey or NOCC Rota for IBM compatable floppy disk copies.

NO.	PORT
*1	GAETA, ITALY
*2	NAPLES, ITALY
*3	CATANIA, ITALY
*4	AUGUSTA BAY, ITALY
*5	CAGLIARI, ITALY
*6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONACO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
16	BARCELONA, SPAIN
17	PALMA, SPAIN
18	IBIZA, SPAIN
19	POLLENSA BAY, SPAIN
20	LIVORNO, ITALY
21	LA SPEZIA, ITALY
22	VENICE, ITALY
23	TRIESTE, ITALY
*24	CARTAGENA, SPAIN
*25	VALENCIA, SPAIN
*26	SAN REMO, ITALY
*27	GENOA, ITALY
*28	PORTO TORRES, ITALY
*29	PALERMO, ITALY
*30	MESSINA, ITALY
*31	TAORMINA, ITALY

1991	PORT
*32	TARANTO, ITALY
*33	TANGIER, MOROCCO
*34	BENIDORM, SPAIN
*35	ROTA, SPAIN
*36	LIMASSOL, CYPRUS
*37	LARNACA, CYPRUS
*38	ALEXANDRIA, EGYPT
*39	PORT SAID, EGYPT
*40	BIZERTE, TUNISIA
*41	TUNIS, TUNISIA
*42	SOUSSE, TUNISIA
*43	SFAX, TUNISIA
*44	SOUDA BAY, CRETE
	VALETTA, MALTA
	PIRAEUS, GREECE

1992	PORT
	KALAMATA, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	THESSALONIKI, GREECE

DELAYED INDEFINITELY

ALGIERS, ALGERIA
ISKENDERUN, TURKEY
IZMIR, TURKEY
ISTANBUL, TURKEY
ANTALYA, TURKEY
GOLCUK, TURKEY

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.

B. Cruise reports were reviewed.

C. Navy personnel with current or previous area experience were interviewed.

D. A preliminary report was developed which included questions on various local conditions in specific harbors.

E. Port/harbor visits were made by NOARLW personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.

F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,
B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,
C. local wind wave conditions, and
D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2 CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The

oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested precautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of Bizerte (Banzart), Tunisia is located on the North African coast at approximately 37°17'N 09°53'E (Figure 2-1).

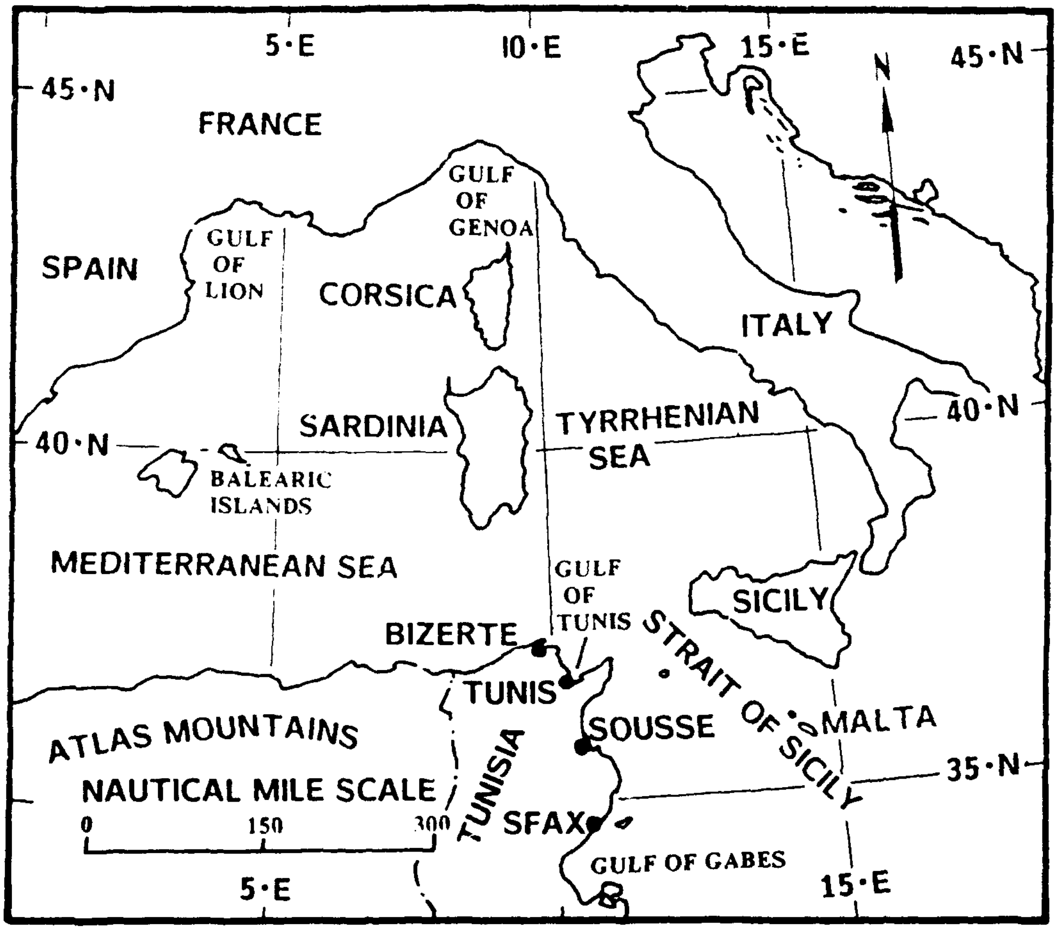


Figure 2-1. West and Central Mediterranean Sea.

Bizerte is situated about 4 n mi south of Point Banzart, which is just east of Point Gueurn Djediane, the northernmost point of land in North Africa (Figure 2-2). The terrain to the west of the port is hilly, with elevations to 900 ft (274 m) existing within 3 n mi of the port.

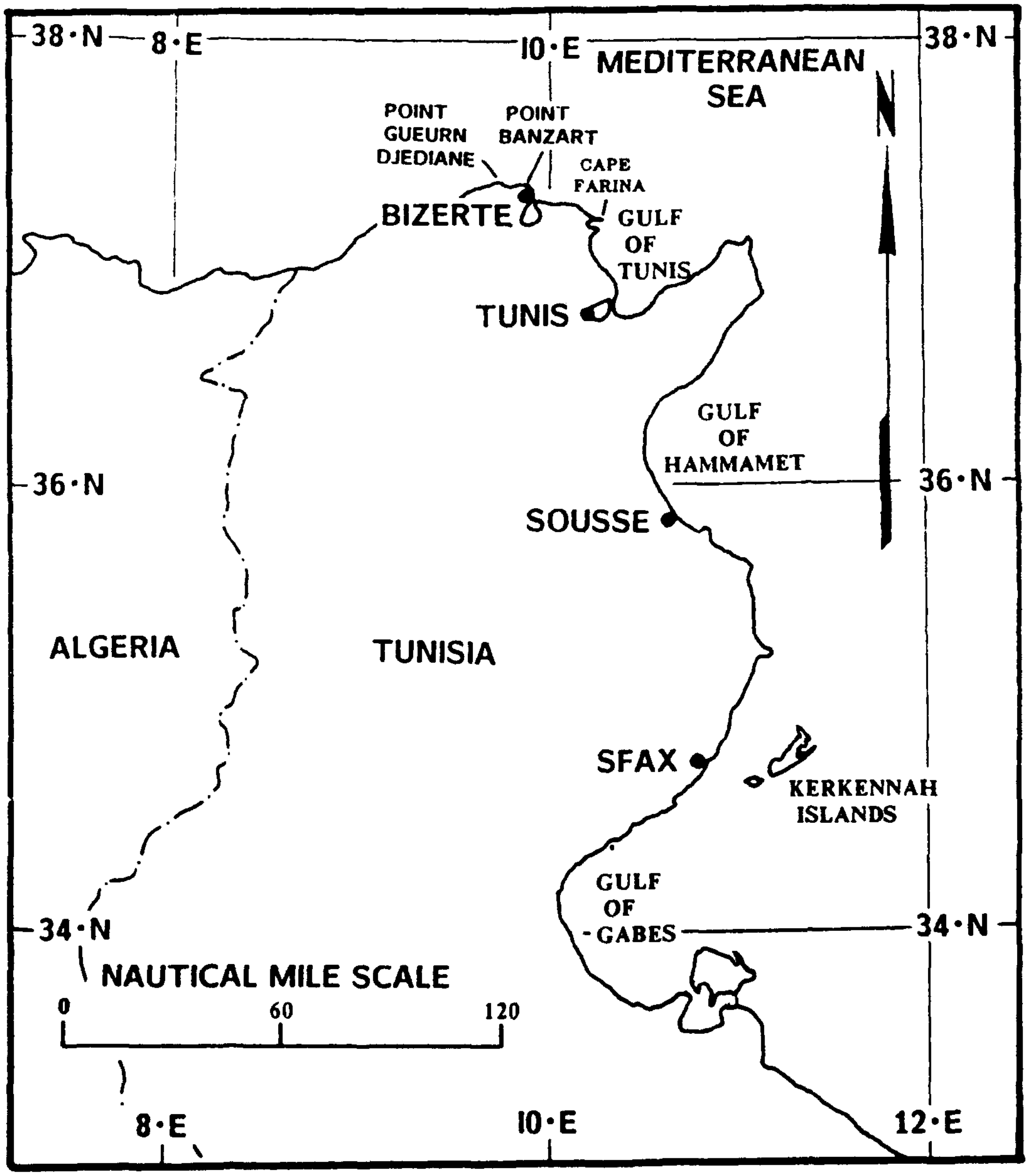


Figure 2-2. Tunisia and adjacent waters.

The Port of Bizerte consists mainly of the Outer Port (Avant Port), Old Port (Vieux Port), the channel (Le Canal), Lake Goulet (Goulet du Lac) (Figure 2-3) and Anse de Sidi Abd'Allah on Lake Bizerte (Buhayrat Banzart or Lac de Bizerte) (Figure 2-4). The city of Bizerte is located principally northwest of the channel.

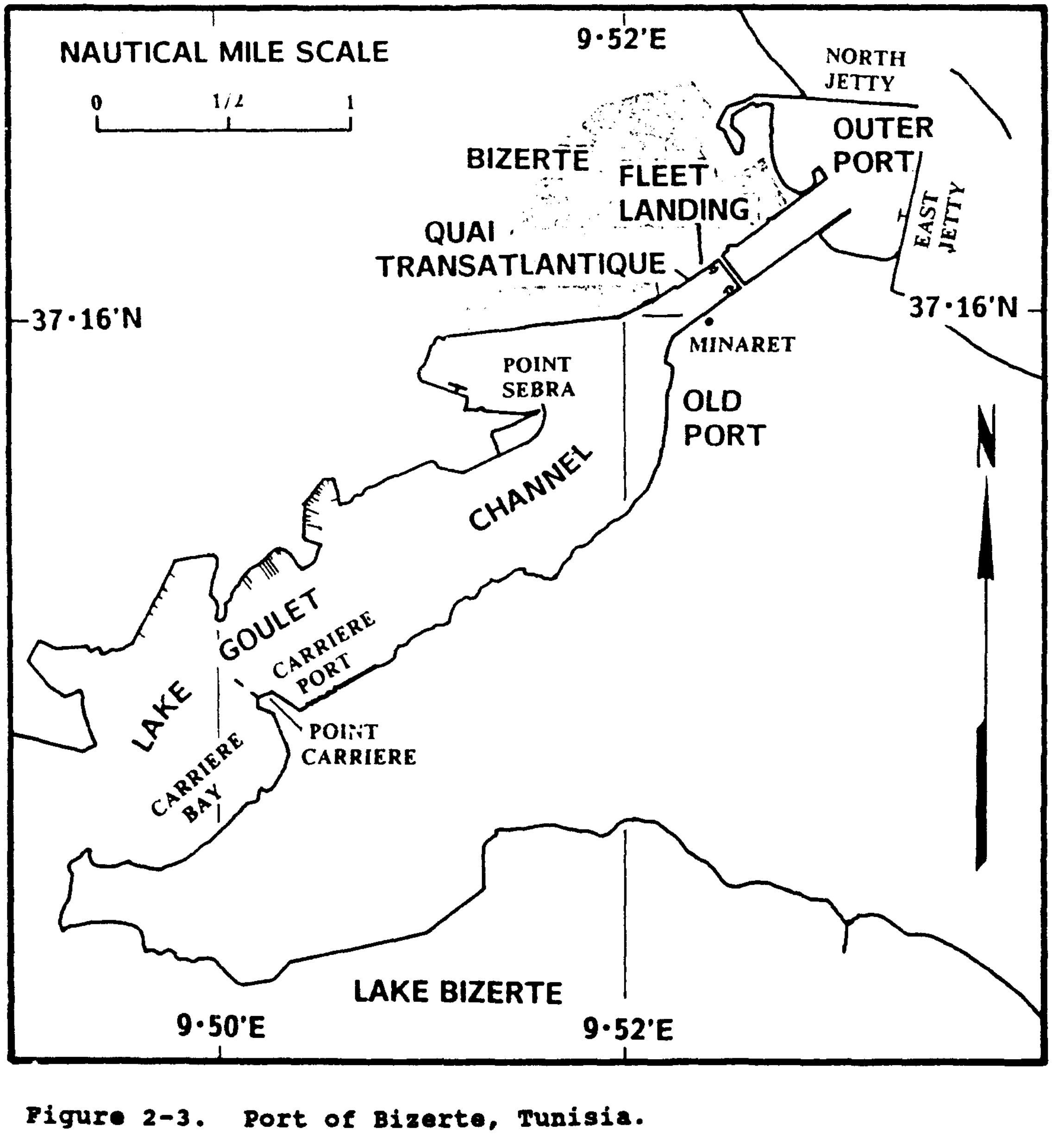


Figure 2-3. Port of Bizerte, Tunisia.

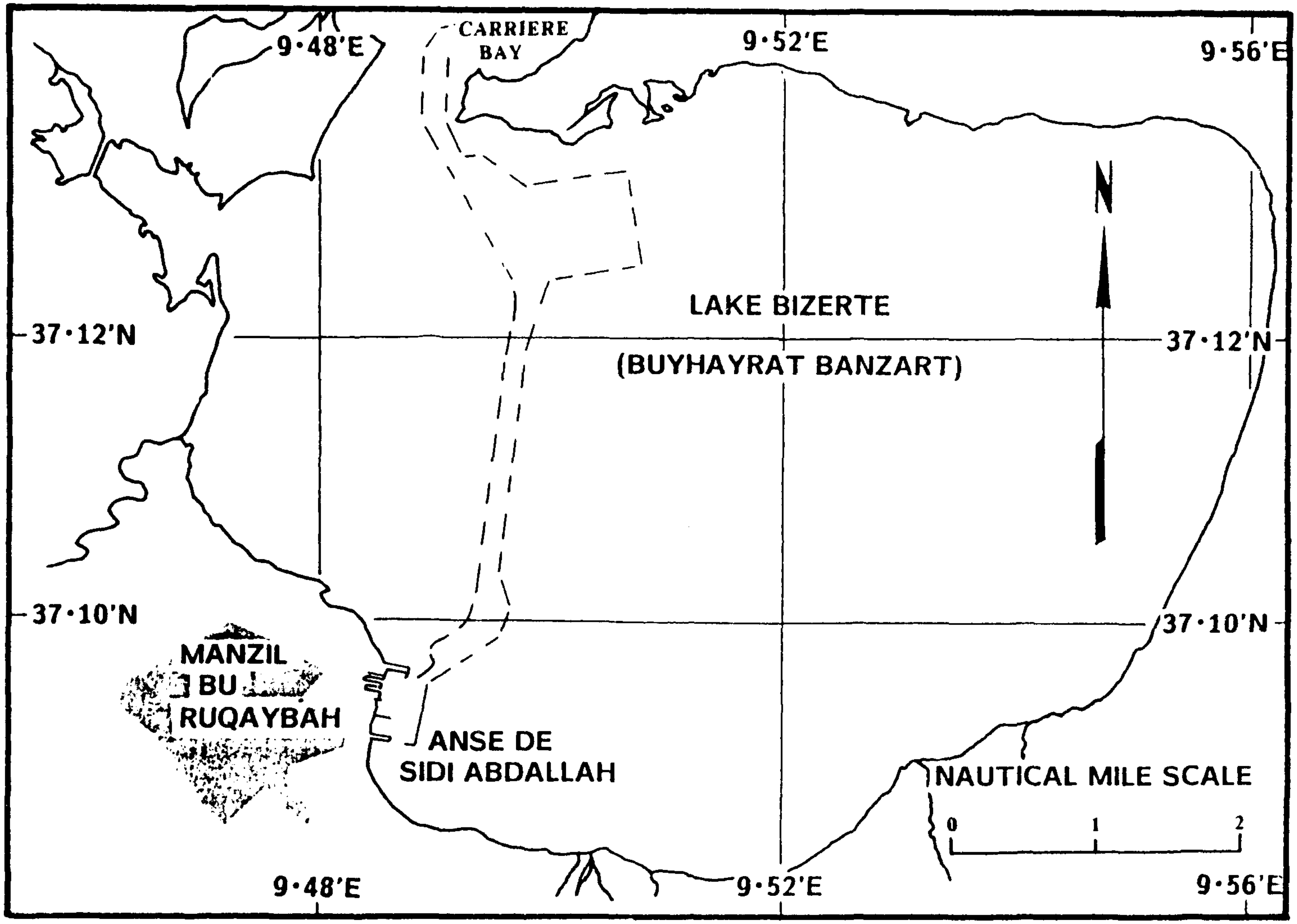


Figure 2-4. Lake Bizerte with location of dry dock facilities at Anse de Sidi Abdallah.

The port is protected by two jetties. The north jetty is 3,363 ft (1,025 m) long, and the east jetty is 3,084 ft (940 m) long. The entrance between the jetties is protected by a 2,001 ft (610 m) breakwater (FICEURLANT, 1989). Only the south-eastern entrance to the harbor is considered safe for U. S. Navy ships.

Berths for Navy ships are located on Quai Trans-atlantique, on the north side of the channel just past the draw bridge. The following procedures were defined during a visit to the port. During ebb tide, proceed directly to the assigned berth and tie up starboard side to the pier. During flood tide, proceed past the berth to the turning basin, where tugs will help the ship turn around, then return to the assigned berth and tie up port side to the pier

Point Carriere (Figure 2-3) is the only place in Bizerte where submarines may berth. FICEURLANT (1989) states that Carrieres Pier allows for positioning two destroyer types bow to stern alongside. The Outer Port has tanker berths near the middle of the east jetty.

A fleet landing will normally be established in the port for ships not tied up to the Quai Transatlantique. Infirmerie Landing at the Naval Base (Carriere Port) is also used (FICEURLANT, 1989).

The primary anchorage area is located 1/2 n mi east of the outer breakwater. Local authorities recommend that when force 7-8 (28-40 kt) northwesterly winds are blowing in the roadstead at least 109 fm (200 m) of chain be used to minimize anchor dragging on the mud bottom. Underwater cables to the west of the harbor entrance prevent its use as an anchorage.

FICEURLANT (1989) describes an anchorage in the Outer Port off the entrance of the Old Port and as close as possible to the north jetty. In this area, however, seaweed may be pumped into condensers. The same document states that anchorage is available to large ships southeast of Point Sebra, off Quai de la Carriere, and in Baie des Carrieres. The holding ground is good.

Currents in the port are tide dependent. The current reaches a maximum of 4 kt in the channel and 2 to 4 kt outside the channel, depending on the stage of the tide. The maximum tidal range is less than 3 ft (0.9 m), and is influenced by the weather.

Specific hazardous conditions, vessel situations, and suggested precautionary/evasive action scenarios are summarized in Table 2-1.

Table 2-1. Summary of hazardous environmental conditions for the

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCA SITUATION AF
1. NW winds/waves - * Winds to 40-50 kt. * Waves commonly exceed 10 ft. * Primarily occur October through May.	Advance warning. * Can be expected at Bizerte 2 days after strong mistral begins in Gulf of Lion. Duration. * Winds will blow until mistral ceases. Waves will persist for 1-2 days after winds diminish in Gulf of Lion.	(1) Moored - C (2) Moored - Port. (3) Anchored harbor. (4) Arriving departin (5) Small boa

ous environmental conditions for the Port of Bizerte (Banzart), Tunisia

RS OF HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
ted at Bizerte 2 trong mistral f of Lion. low until mis- Waves will -2 days after in Gulf of	(1) Moored - Old Port.	(a) Little significant effect. * Mooring lines may need to be doubled/added to preclude undue ship movement alongside the piers.
	(2) Moored - Outer Port.	(b) Ships in the Outer Port will experience stronger winds than those in the Old Port. * Mooring lines may need to be doubled/added to preclude undue ship movement.
	(3) Anchored - outer harbor.	(c) Worst conditions for the anchorage. * Strong winds and waves exceeding 10 ft will impact ships in the anchorage. * When wind is 28-40 kt (force 7-8), ships will need to use at least 109 fm (200 m) of chain to prevent dragging. * Stronger winds may dictate a move to better protected waters south of Cape Farina (about 20 n mi E of Bizerte).
	(4) Arriving/ departing.	(d) Strong winds can severely impact arriving/ departing vessels. * Vessels that need to transit the channel to points W of the draw bridge should be aware that the bridge cannot be raised when the winds reach the 35-40 kt range. * Outbound vessels must stay in the port and inbound vessels must stay out of the port until the winds abate.
	(5) Small boats.	(e) Some small boat operations will be affected. * Runs to/from the anchorage outside the harbor likely to be curtailed in a strong event. * Small boat operation within the confines of the Old Port/Outer Port should be only minimally affected.

Table 2-1. (Continued)

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATI SITUATION AFFE
2. E - NE'ly winds/waves - * Waves in the anchorage are generally limited to about 5 ft.	Advance warning. * Any synoptic situation which indicates that a N African low moving S of the Atlas Mountains will pass S of Bizerte before moving E into the Gulf of Gabes. * Any synoptic situation which indicates that a low over the Gulf of Genoa will be moving into the Tyrrhenian Sea.	(1) Moored - Ol (2) Moored - Out Port. (3) Anchored - c harbor. (4) Arriving/ departing. (5) Small boats.

Table 2-1. (Continued)

ETORS OF AL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
.c situation which :hat a N African :S of the Atlas ‡ill pass S of :ore moving E into : Gabes. .c situation which that a low over ; Genoa will be .. the Tyrrhenian	(1) Moored - Old Port.	(a) Little significant effect. * Mooring lines may need to be doubled/added to preclude undue ship movement alongside the piers.
	(2) Moored - Outer Port.	(b) Little significant effect. * Ships in the Outer Port will experience stronger winds than those in the Old Port. Mooring lines may need to be doubled/added to preclude undue ship movement.
	(3) Anchored - outer harbor.	(c) Anchorage will be affected. * Ships may need to use extra chain to preclude dragging anchor. * Otherwise, little significant effect unless very strong event occurs.
	(4) Arriving/ departing.	(d) Strong winds can severely impact arriving/ departing vessels. * Vessels which need to transit the channel to points W of the draw bridge should be aware that the bridge cannot be raised when the winds reach the 35-40 kt range. * Outbound vessels must stay in the port and inbound vessels must stay out of the port until the winds abate. * Inbound vessels should be aware that E winds tend to cause steering problems and force vessels entering the harbor onto the breakwater.
	(5) Small boats.	(e) Small boat runs may be affected. * Runs to/from the outer anchorage may need to be curtailed. * NE winds would be roughly parallel to the orientation of the channel, so small boat operations in the channel could be in jeopardy in a strong NE wind situation.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November through February):

* Northwest winds and waves.
  * Wind speeds may reach 40-50 kt.
  * Swell of 10-13 ft (3-4 m) common in anchorage outside breakwater.
    * Waters south of Cape Farina will afford better protection for anchored vessels.
  * Draw bridge cannot be raised when wind reaches 35-40 kt.
    * Ships cannot enter/exit Old Port.
  * Usually occurs 2 days after onset of a strong mistral in Gulf of Lion.
* East and northeast winds and waves.
  * May cause steerage problems for ships entering the port.
    * Tends to force ships toward breakwater.
  * Swell to 5 ft in anchorage is common.

SPRING (March through May):

* Northwest winds and waves continue to be a threat to the port until late in the season.
* East and northeast winds and waves are possible until late in the season.

SUMMER (June through September):

* Summer weather is generally settled.
* By September, the threat of strong northwesterly winds increases. See winter section above.
* Daily sea/land breeze regime does not hamper port operations.

AUTUMN (October):

* Short transitional season with winter-like weather returning by month's end.

NOTE: For more detailed information on hazardous weather conditions, see previous Table 2-1 in this section and Hazardous Weather Summary in Section 3.

REFERENCES

FICEURLANT, 1989 (Change 2): Port Directory for Bizerte (Banzart), Tunisia. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

PORT VISIT INFORMATION

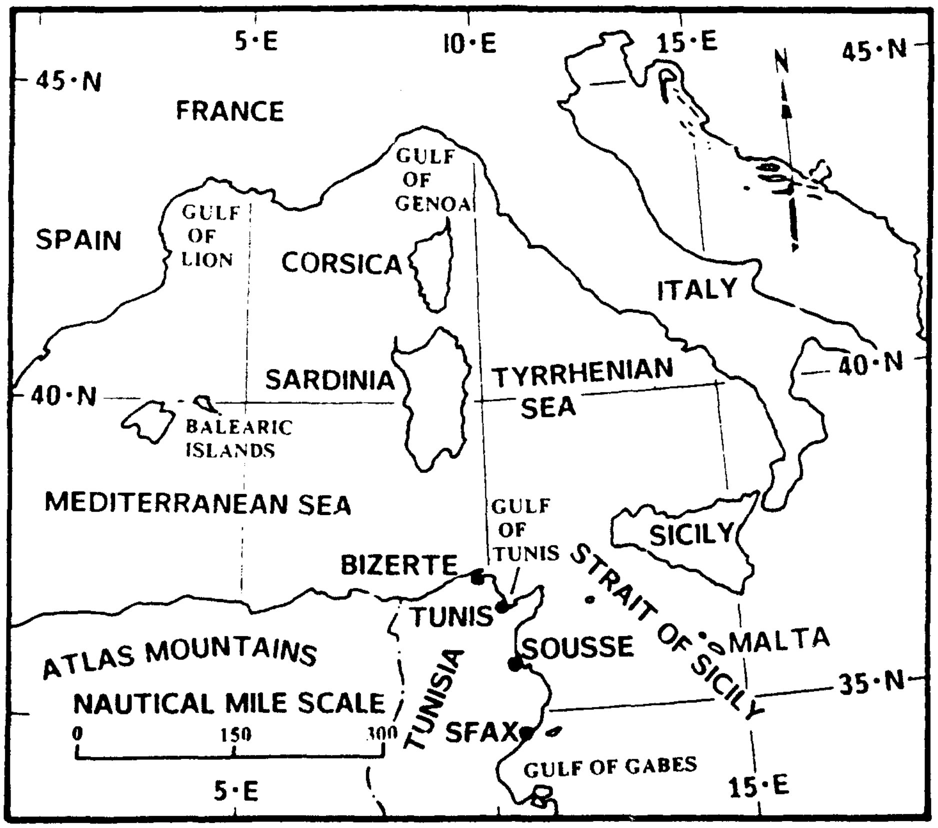
JANUARY 1990. NOARL Meteorologists R. Fett and Lieutenant M. Evans, U.S. Navy, met with Port Director Omar Majdoub, Port Captain Ben Fadhel Sahbene, and Pilots Cherif Mohamed Elhedi and Ben Hassen Hassen to obtain much of the information included in this port evaluation.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and table 3-1 provides a summary of vessel locations/situations, potential hazards, effect-precautionary/evasive actions, and advance indicators and other information about potential hazards by season.

3.1 Geographic Location

The Port of Bizerte (Banzart), Tunisia is located on the North African coast at approximately 37°17'N 09°53'E (Figure 3-1).



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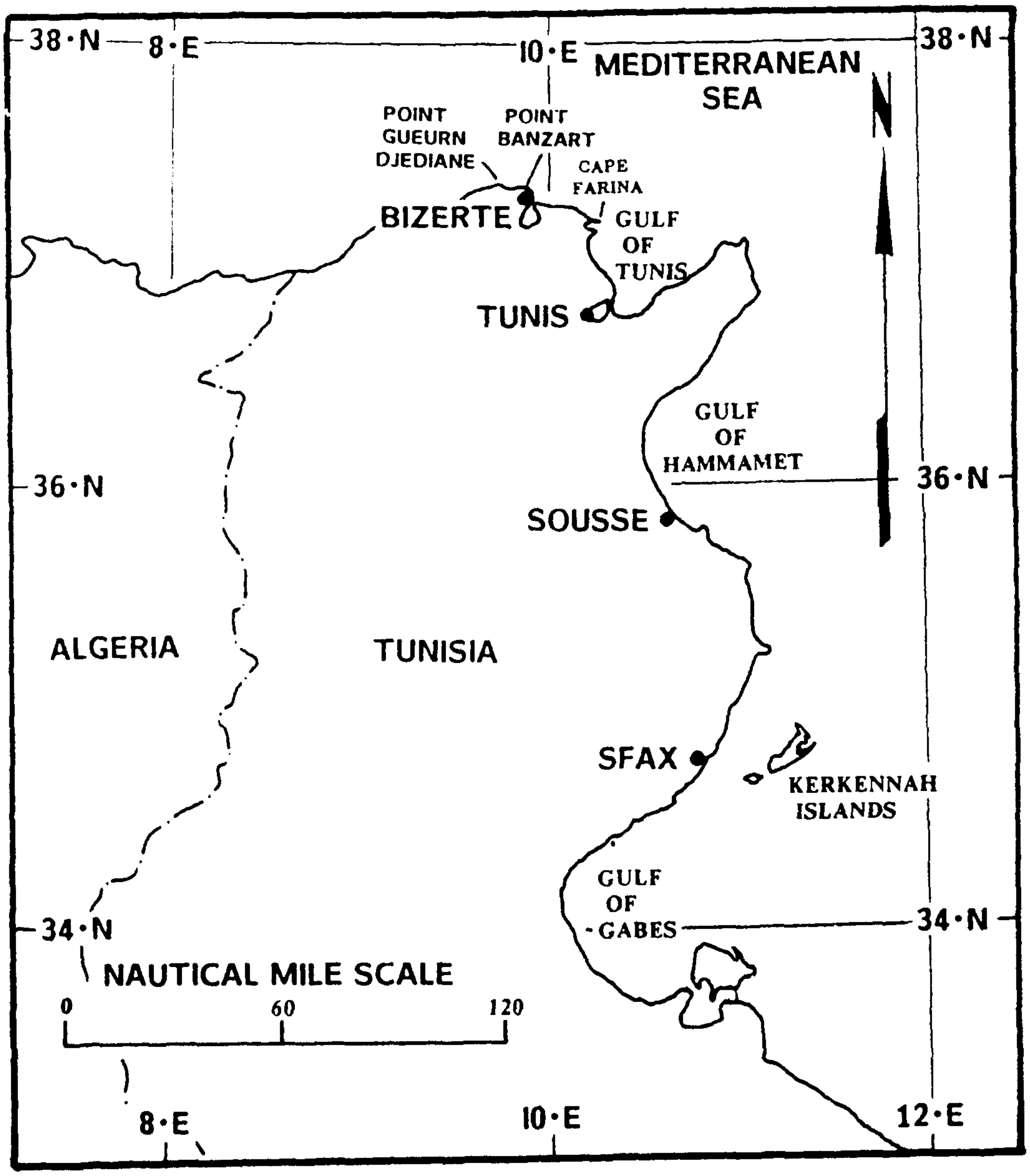

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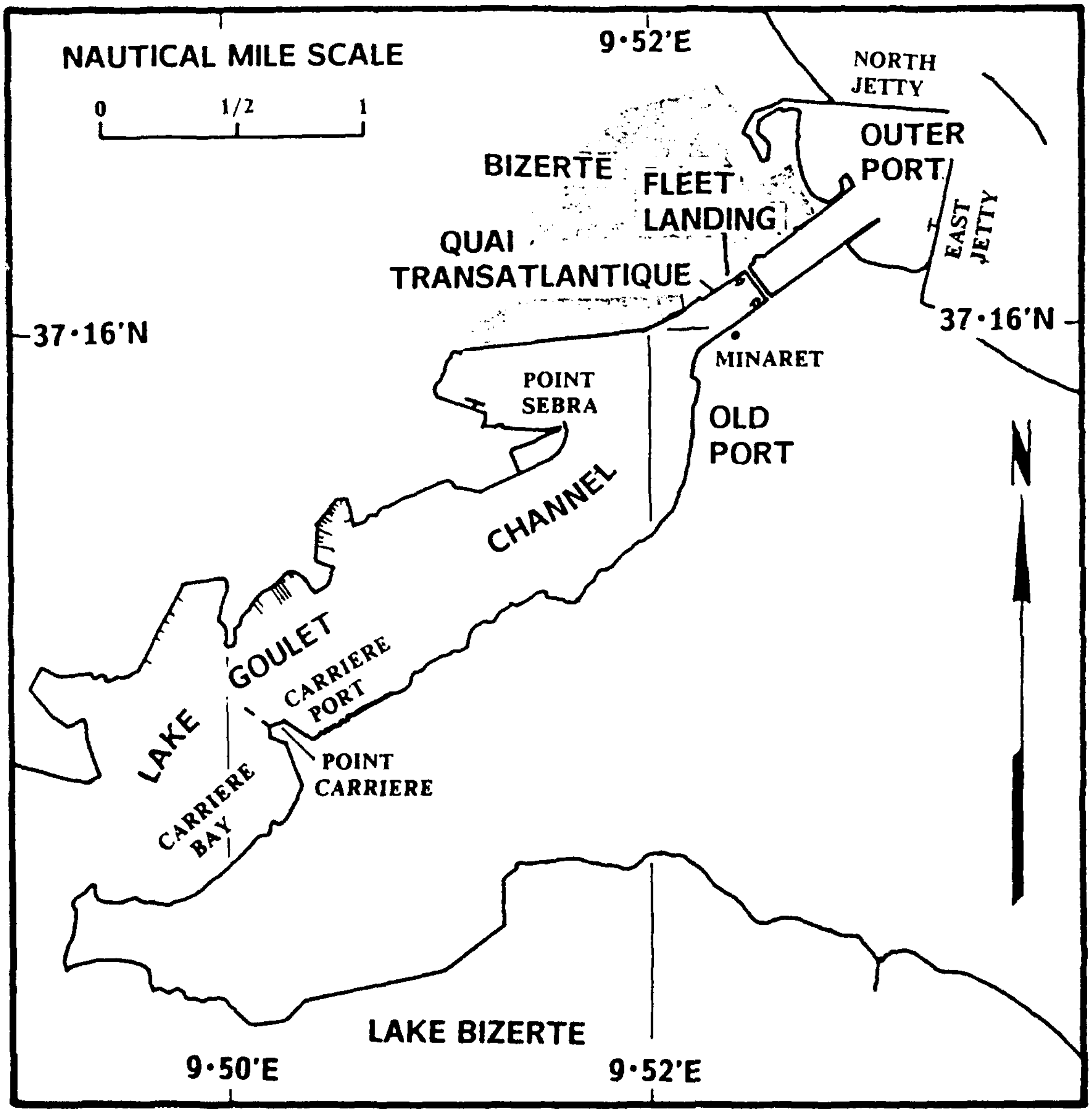
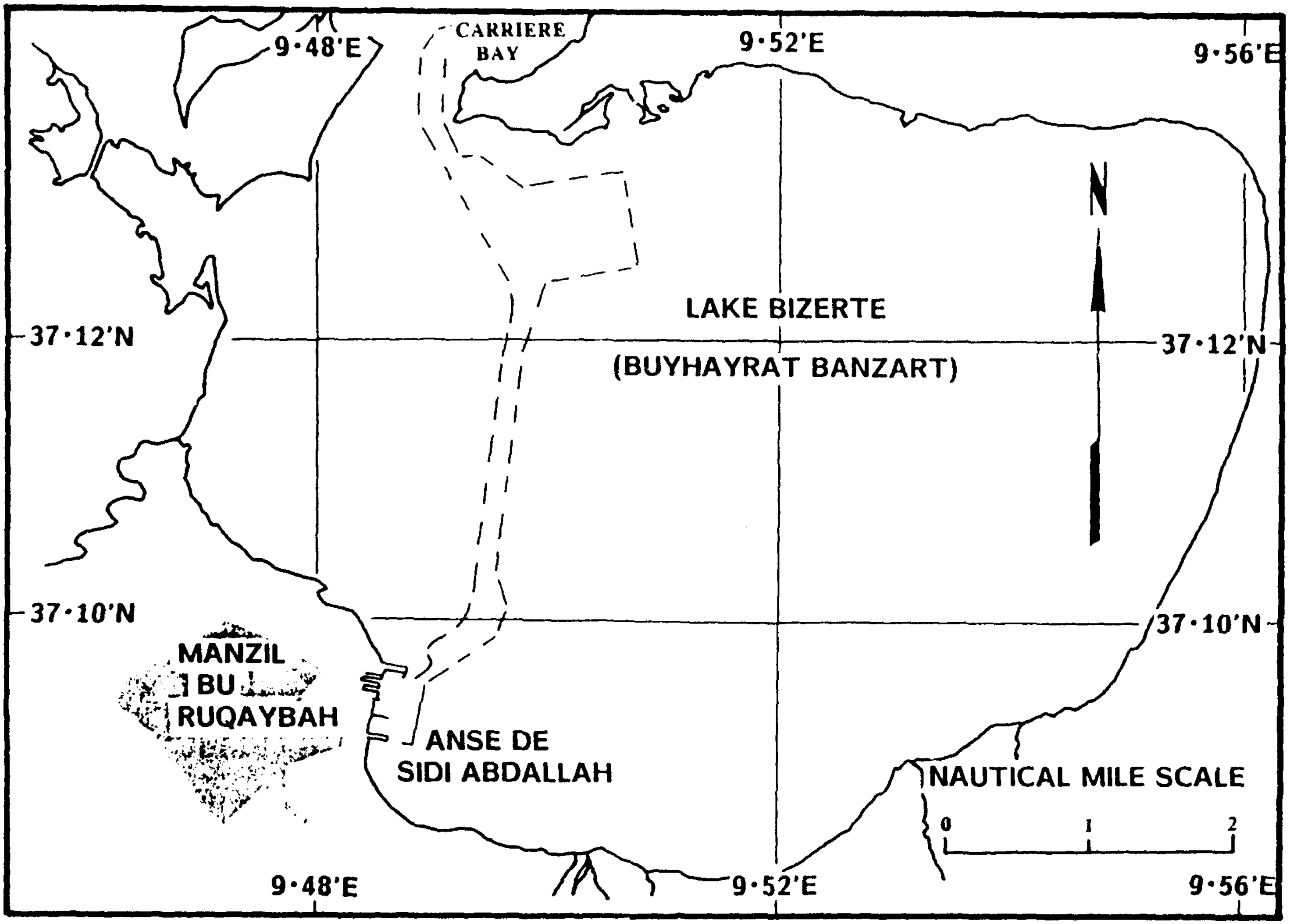


Figure 3-3. Port of Bizerte, Tunisia.



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The primary anchorage area is located 1/2 n mi east of the outer breakwater. Local authorities report that when strong (28-40 kt (force 7-8)) northwesterly winds are blowing in the roadstead, at least 109 fm (200 m) of chain is required to prevent dragging anchor on the mud bottom. Underwater cables to the west of the harbor entrance prevent its use as an anchorage.

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available to large ships southeast of Point Sebra, off Carriere Pier, and in Carriere Bay. The holding ground is good.

3.2 Qualitative Evaluation of the Port of Bizerte

While local authorities did not specifically address the qualities of the port, the protection afforded the inner port by the breakwater/jetty configuration and the orientation of the channel on which Navy ships moor indicates the port would provide good protection from most hazardous weather scenarios.

Some problems do exist, however. The commonly observed strong northwesterly winds and waves impact the anchorage, and a sortie to a better protected anchorage may be necessary. Also, in winds of 35-40 kt, the drawbridge cannot be raised, and ships can neither enter nor exit the port until the winds abate.

Local authorities state that east and northeast winds can cause steerage problems when entering the port, tending to push ships into the breakwater.

Drydock facilities are located on the southwest side of Lake Bizerte. Transiting the lake at night is not recommended, so ships cannot be brought into the drydock area at night.

3.3 Currents and Tides

Currents in the port are tide dependent. The current reaches a maximum of 4 kt in the channel and 2 to 4 kt outside the channel, depending on the stage of the tide. The maximum tidal range is less than 3 ft (0.9 m), and is influenced by the high winds.

3.4 Visibility

Fog occurs during early mornings on about 4 or 5 days per year, but burns off quickly. When occurring, fog reduces visibility to about 100 m.

3.5 Hazardous Conditions

Northwest winds and waves are a major problem at the port, especially in the anchorage. The winds can reach 40 to 50 kt from October through May. Near gales (28-33 kt, force 7) are most frequent (2 to 4 days per month) from November to April, and are rare in June. East and northeast winds can cause steerage problems when entering the port. With winds of 35-40 kt, the draw bridge cannot be raised, and ships can neither enter nor exit the port.

Although uncommon, storms having tropical characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean Basin. On one occasion, September 1983, the storm moved northwest from the Gulf of Gabes (Figure 3-2), through the Straits of Sicily, along the east coast of Sardinia, and into the Gulf of Genoa. While the wind speeds at Bizerte are not known, winds of 100 kt were observed near the eye. While the probability of such a storm striking Bizerte is very slight, the forecaster must be aware of the possibility.

An average of 24.7 inches of precipitation is recorded at Bizerte during an average year. Figure 3-5 shows the annual distribution.

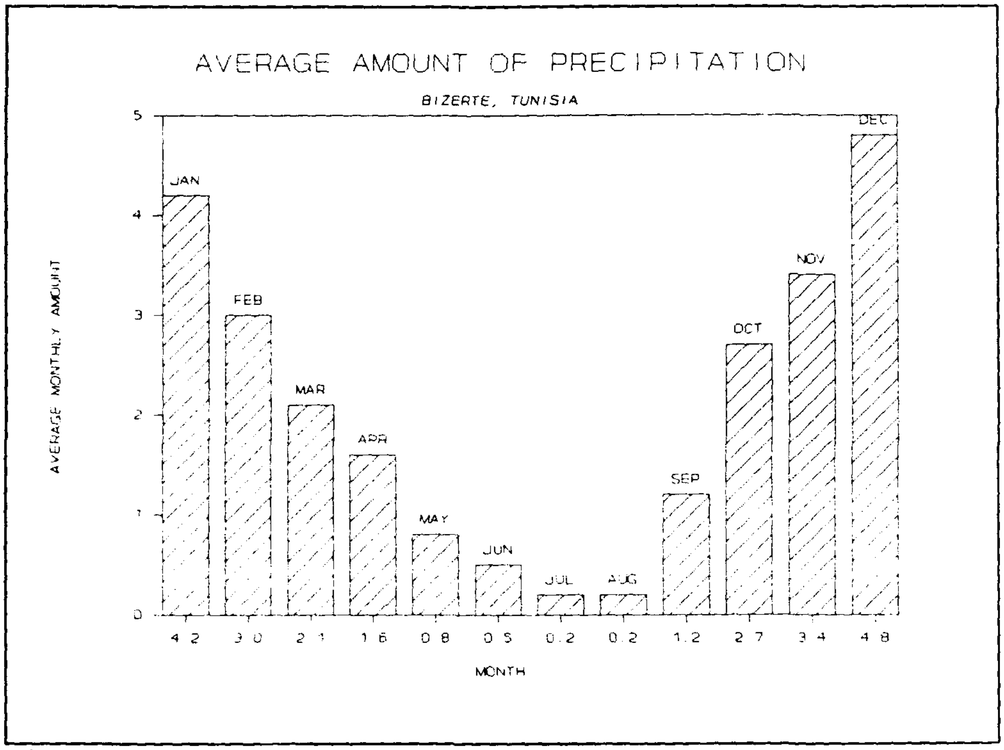

Figure 3-5. Precipitation. (After Biel, 1946.)

A seasonal summary of various known environmental hazards that may be encountered in the Port of Bizerte follows.

A. Winter (November through February)

(1) Northwesterly winds and waves. Prevailing winds at Bizerte during the winter are from the west to northwest, and a major threat to the port is created by strong northwesterly winds and waves. The winds can reach 40 to 50 kts, and be accompanied by swell waves exceeding 10 ft in the anchorage. Local authorities state that they occur primarily from October through May, and can be anticipated two days in advance of

onset because they can be associated with mistral events in the Gulf of Lion.

Brody and Nestor's Regional Forecasting Aids for the Mediterranean Basin thoroughly discusses mistral events. To enable the meteorologist visiting Bizerte to better understand the threat of northwesterly conditions, the following information is excerpted from Brody and Nestor's document.

> Mistral. The mistral is a cold, strong northwesterly to north-northeasterly offshore wind along part or all of the coast of the Gulf of Lion. Its influence occasionally extends beyond the Gulf of Lion to affect the weather of the entire Mediterranean basin.
>
> The mistral is the result of a combination of the following factors:
>
> (1) The basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.
>
> (2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.
>
> (3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.
>
> (4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).
>
> Mistral wind speeds often exceed 40 kt and occasionally have reached 100 kt in gusts along the coastal region from Marseille to Toulon. Over the open water in the Gulf of Lion, mistral wind speeds locally greater than 40 kt occurred in nearly 8% of total observations.
>
> The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing southeastward. However, synoptic situations producing severe mistrals will often

produce associated strong wind regimes extending as far as North Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring.

Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface.

North African Low. Another potential cause of strong north to northwesterly winds at Bizerte is a North African low which moves northeastward across the coast of Tunisia toward Sicily. See section 3.5.A.(2) below. Strong winds are likely to the west of the northeastward tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb) (Brody & Nestor, 1980).

(2) East and northeast winds. East and northeast winds have a less severe impact at Bizerte than northwest winds, but affect port operations by causing steering difficulties for ships entering the port. The winds can have several causes, including the development and passage of North African lows south of Bizerte. The following has been extracted from Brody & Nestor, 1980.

North African lows develop over the desert region south of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying northeast-southwest, producing a deep southwesterly flow over northwest Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range.

The lows which have the potential to produce east and northeasterly winds at Bizerte follow an eastward track south of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at or near the Gulf of Gabes. When North African lows occur south of the Atlas Mountains, strong easterly to southeasterly winds are likely over the southern Mediterranean and will result in high seas in the Strait of Sicily.

A North African low is most likely to form over Tunisia when the long-wave trough is oriented northeast-southwest across the Tyrrhenian Sea. Cold continental polar air will be advected in from eastern Europe and a pocket of cold air (-25°C at 500 mb) will form between Sardinia, Sicily and Tunisia. The subtropical jet also will be evident over North Africa. Wind speeds at 500 mb over Tunisia and Libya will be 55 kt or more.

The speed of movement with these systems is related to the time of year in which they develop. During late autumn and early winter, lows moving out of this area are noted for their extremely slow movement due to their association with a cut-off low aloft.

During late winter and early spring, as the number of North African cyclones increases, North Africa becomes the primary cyclogenesis area for the region. Unlike lows developing early in the winter, these lows are generally associated with open, short wave troughs. They produce little precipitation, but frequently produce high winds in close proximity to their centers. Their increased speed of movement compared with the early winter systems also make them unique. Some lows have been noted to move eastward out of North Africa at 40 to 50 kt. With the scarcity of

reports along the cyclogenesis area, the use of satellite data over the region may be the only clue to the presence of a developing low.

COMSIXTHFLT ltr 3140 Ser N312/003 (4 Jan 1990) addresses a specific weather event that took place on Malta (Figure 3-1) during 30 November 1989 through 3 December 1989, the period of well publicized Bush-Gorbachev talks. Although Malta is located on the eastern end of the Strait of Sicily some 240 n mi east-southeast of Bizerte, the general weather scenario was one which would result in easterly conditions at Bizerte. A resumé follows.

> The USS Belknap was anchored in "Pretty Bay," Marsaxlokk, Malta from 26 November through 4 December 1989. The Soviet Navy cruiser, Slava, anchored about 500 yds southeast of Belknap on 28 November. The synoptic situation that caused the "Malta Meeting storm" was a classic "Gregale" existing in conjunction with an Adriatic and Aegean Bora as defined in Chapter V, paragraph 2.4 of Brody and Nestor (1980). A strong omega block dominated the European weather pattern from late November through the period of the Bush-Gorbachev meetings on 2-3 December. A strong ridge with 500 mb height maximum centered near Austria/Czechoslovakia separated a cut-off low west of the Iberian Peninsula from a major long-wave trough over the western Soviet Union. A ridge of high pressure extended south across Italy and the Straits of Sicily from the center over the continent. Winds at Malta were east-southeasterly about 20 kt on 29 and 30 November.
>
> A short-wave trough and jet max rotating around the eastern Europe long-wave trough moved south across Italy on 30 November/1 December. At the same time, a weak Tunisian low formed south of the Atlas mountains and moved east to the Gulf of Gabes. When it reached the water on 1 December, it intensified in response to the energy source of the warm water and the approaching short wave. About 020230Z winds backed to northeast and increased to 28-30 kt.

> Belknap dragged her stern anchor and the Slava dragged her stern buoy.
>
> The low moved south of Malta and pressure began to rise at 020000Z. However, infrared pictures from METEOSAT showed an indication of a second circulation in the Gulf of Gabes. At 020900Z the pressure began to fall rapidly as winds increased and rain showers became nearly continuous. Minimum pressure was reached at 021200Z, but the gradient between the low and the strong ridge to the north maintained gale force winds throughout the afternoon. Once again satellite data showed a possible circulation center developing on the east coast of Tunisia.
>
> The third low pressure center in the Gulf of Gabes further increased the northeast gradient on the evening of 2 December. Between 1800Z and 2000Z the wind rarely decreased below 40 kt. Maximum strength was reached about 1840Z, with sustained winds of 48 kt gusting to 55 kt for about 15 minutes. After 1855Z, winds began to slowly diminish, settling in the 30-35 kt range until 030500Z, when they decreased to 20-25 kt with higher gusts in precipitation.

Strong easterly winds at Bizerte can also be caused by complex low pressure systems with multiple centers at the surface which are a common event in the western Mediterranean basin. One center usually can be found in the Gulf of Genoa, and another over North Africa; a weak pressure gradient exists between the two systems. Which of these lows will develop depends greatly on the movement of an upper-level (500 mb) shortwave trough (SD minimum). If, for example, the SD minimum moves to the North African coast, the low center in that region will develop; this rapidly increases the pressure gradient, and causes easterly gales over the southern and central portions of the Mediterranean (Brody & Nestor, 1980).

Local authorities state that southerly winds, which may precede the arrival of North African lows, are hot but do not carry sand.

As can be seen in Figure 3-5, Bizerte receives most of its precipitation during the winter, with December being the wettest month. During December and January, precipitation occurs on an average of 15 days each month (Biel, 1946).

Temperatures at Bizerte are generally mild in January, the coldest month of the year, with a mean daily maximum temperature of 58°F (14°C) and a mean daily minimum of 46°F (8°C). Freezing temperatures (32°F) have been recorded at Bizerte (Hydrographic Department, 1963).

B. Spring (March through May)

The early spring season is much the same as winter. See section 3.5.A above. The cause of strong northwesterly winds at Bizerte, the mistral over the Gulf of Lion, is observed through May. North African lows, the common cause of east and northeasterly winds are at their yearly maximum frequency of occurrence during spring. But after April the events become more infrequent and by the end of May summer weather usually prevails.

As can be seen in Figure 3-5, precipitation at Bizerte diminishes rapidly during spring. By May, the average monthly accumulation has decreased to only 0.8 inches (Hydrographic Department, 1963).

Temperatures gradually increase as spring progresses but remain relatively comfortable, even at the end of the season. During May, the mean daily maximum temperature is 73°F (23°C), and the mean daily minimum temperature is 59°F (15°C) (Hydrographic Department, 1963).

C. Summer (June through September)

Summer weather is generally settled, with the more hazardous weather events occurring only rarely. Strong mistral events in the Gulf of Lion do not normally occur from June through August, so strong northwesterly winds are uncommon during most of the summer at Bizerte. North African low activity is also infrequent. By September, however, the possibility of strong mistral events over the Gulf of Lion increases, and the commensurate threat of strong northwesterly winds at Bizerte also increases.

There is a sea/land breeze regime at Bizerte, but the wind speed is limited to about 11-16 kt (force 4) so it is not a hazard to the port.

Precipitation is at a yearly minimum during summer (see Figure 3-5), with July and August having an average of only 0.2 inches of accumulation during each month (Hydrographic Department, 1963).

Temperatures are warmest during July and August, with a mean daily maximum of 85°F (29°C). A mean daily minimum temperature of 72°F (22°C) is recorded during August. The absolute maximum recorded temperature is 110°F (43°C), but the mean of the highest temperatures recorded each year is only 101°F (38°C) (Hydrographic Department, 1963).

D. Autumn (October)

Autumn is a short, transitional season in the Mediterranean Basin, lasting only for the month of October. It results in an abrupt change from summer weather to the unsettled weather of winter (Brody and Nestor, 1980). Strong mistral events over the Gulf of

Lion are possible, with resultant strong northwesterly winds affecting the Port of Bizerte. See section 3.5.A above. North African lows (also discussed in section 3.5.A above) moving eastward south of the Atlas Mountains before moving into the central or eastern Mediterranean Sea are increasingly frequent as winter approaches, so strong east and northeasterly winds are also possible.

Precipitation continues its increase from the lows of mid-summer, with 2.7 inches observed on average during October. See Figure 3-5.

Temperatures start to decrease as winter approaches but are still mild. The mean maximum temperature for October is 77°F (25°C) and the mean minimum temperature is 63°F (17°C).

3.6 Harbor Protection

Portions of the port offer good protection from some hazards, but other areas, as detailed below, are exposed and vulnerable to hazardous weather scenarios.

3.6.1 Wind and Weather

Port facilities on the canal are well protected from strong northwesterly winds, the prime wintertime hazard at Bizerte. The same facilities are more exposed to east and northeast winds, but properly moored vessels should experience no major problems. Ships moored in the outer port (Avant Port) are more exposed to northwesterly winds than are ships in the canal, and are completely exposed to east and northeast winds. As with ships moored in the canal, however, properly moored vessels should experience no major problems.

Problems for ships either inbound or outbound are more significant, because the drawbridge crossing the canal cannot be raised with winds of 35-40 kt, and ships can neither enter nor exit the port. Also, easterly winds cause steerage problems for ships entering the port as they tend to force vessels into the breakwater.

The anchorage is fully exposed to the effects of strong northwesterly winds. The use of at least 109 fm (200 m) of chain is recommended by local authorities to minimize anchor dragging.

3.6.2 Waves

It was determined during a visit to Bizerte that there is no significant wave motion in the harbor but that northwest swell reflects off the fishing port (exact location not specified). Northwest swell greater than 10 ft is common in the anchorage. Local authorities state that on one occasion northwest swell was so bad that the pilot couldn't get back onto the pilot boat and had to ride the ship to Hamburg. Swell from northeast to southeast is generally limited to 5 ft.

3.7 Protective and Mitigating Measures

3.7.1 Moving to a New Anchorage

When strong winds are expected from the northwest, ships can find better protected waters by moving south of Cape Farina, 25 n mi east of Bizerte (Figure 3-2).

3.7.2 Scheduling

Because of the inability to raise the draw bridge during high winds, departing vessels which are moored in the canal west of the bridge should get underway prior to onset of

strong winds. For the same reason, arriving vessels should schedule their arrival at the port during periods of light winds.

3.8 Local Indicators or Hazardous Weather Conditions

No local indicators are identified. Meteorologists should be alert for the development of weather scenarios as discussed in section 3.5.A above and briefly addressed below.

Northwest winds - Strong northwest winds (40 or 50 kt potential) can be expected to occur two days after a strong mistral event is observed in the Gulf of Lion during the October through May period.

A difference in surface barometric pressure, with lower pressure to the east, between Perpignan (LFMP/07747), Marseille (LFML/07650) and Nice (LFMN/07690) will give a gauge as to Mistral intensity using the following table (Brody and Nestor, 1980); remembering Mistral winds are highly variable near the coast due to terrain effects:

Pressure Difference (mb)	Perpignan and Nice	Perpignan and Marseille	Marseille and Nice
3		30-35 kt	30-35 kt
4		40 kt	40 kt
5		45-50 kt	45-50 kt
6	30-35 kt		
8	40 kt		
10	45-50 kt		

Note: Higher pressure to west and lower pressure east.

Another potential cause of strong north to northwesterly winds at Bizerte is a North African low which moves northeastward across the coast of Tunisia toward Sicily. Strong winds are likely to the west of the northeastward tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb) (Brody and Nestor, 1980).

East to northeast winds - North African lows have the potential to cause east to northeast winds at Bizerte as they move eastward, south of the Atlas Mountains prior to their passage south of Bizerte, to the Gulf of Gabes.

3.9 Summary of Problems, Actions, and Indicators

Table 3-1 is intended to provide easy-to-use seasonal references for meteorologists on ships using the Port of Bizerte. Table 2-1 (Section 2) summarizes Table 3-1 and is intended primarily for use by ship captains.

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Table 3-1. Potential problem situations at the Port of Bizerte (I

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTION
1. Moored - Old Port. Most common in Winter & Spring, uncommon in Summer, possible by Autumn	a. NW'ly winds/waves - Strong (40-50 kt) NW'ly winds reach Bizerte with waves exceeding 10 ft. Normally result when strong mistral event occurs in Gulf of Lion and extends to Tunisia. Primarily occur October through May.	a. Little significant effect. Mooring lines ma need to be doubled/added to preclude undue ship movement alongside the piers.

Problem situations at the Port of Bizerte (Banzart), Tunisia - ALL SEASONS

-T - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
significant effect. Mooring lines may e doubled/added to preclude undue ship alongside the piers.	a. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France. This pressure gradient is normally associated with Genoa cyclogenesis. (2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed. (3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia. (4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. A diurnal variation in mistral strength is noted, with over-water velocities strongest during the night. Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface. Another possible cause of strong NW winds at Bizerte is the passage of a N African low NE across the coast of Tunisia towards Sicily. Strong winds are likely W of the NE tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb).

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE AC
Most common in Winter & Spring, uncommon in Summer, possible by Autumn	b. E & NE'ly winds/waves - May result from E passage of N African low S of Bizerte. NE winds may be caused by a low pressure system in the Tyrrhenian Sea. Waves in the anchorage are generally limited to about 5 ft.	b. Little significant effect. Mooring li need to be doubled/added to preclude undu movement alongside the piers.

able 3-1. (Continued)

CT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
tle significant effect. Mooring lines may o be doubled/added to preclude undue ship nt alongside the piers.	b. E moving N African lows moving S of the Atlas Mountains prior to their passage S of Bizerte to the Gulf of Gabes are potential sources of strong E or NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range. The lows which produce E and NE'ly winds at Bizerte follow an E'ly track S of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at about 35°N, roughly between Sfax and Sousse. NE'ly winds at Bizerte may also be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa.

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE
2. Moored - Outer Port. Most common in Winter & Spring, uncommon in Summer, possible by Autumn	a. NW'ly winds/waves - Strong (40-50 kt) NW'ly winds reach Bizerte with waves exceeding 10 ft. Normally result when strong mistral event occurs in Gulf of Lion and extends to Tunisia. Primarily occur October through May.	a. Ships in the Outer Port will experienc ger winds than those in the Old Port. Mo lines may need to be doubled/added to pre undue ship movement.

Table 3-1. (Continued)

FFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
ips in the Outer Port will experience stronger winds than those in the Old Port. Mooring may need to be doubled/added to preclude ship movement.	a. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France. This pressure gradient is normally associated with Genoa cyclogenesis. (2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed. (3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia. (4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. A diurnal variation in mistral strength is noted, with over-water velocities strongest during the night. Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface. Another possible cause of strong NW winds at Bizerte is the passage of a N African low NE across the coast of Tunisia towards Sicily. Strong winds are likely W of the NE tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb).

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE
Most common in Winter & Spring, uncommon in Summer, possible by Autumn	b. E & NE'ly winds/waves - May result from E passage of N African low S of Bizerte. NE winds may be caused by a low pressure system in the Tyrrhenian Sea. Waves in the anchorage are generally limited to about 5 ft.	b. Ships in the Outer Port will experie ger winds than those in the Old Port. lines may need to be doubled/added to p undue ship movement.

Table 3-1. (Continued)

CTIO	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
stro ring lude	b. Ships in the Outer Port will experience stronger winds than those in the Old Port. Mooring lines may need to be doubled/added to preclude undue ship movement.	b. E moving N African lows moving S of the Atlas Mountains prior to their passage S of Bizerte to the Gulf of Gabes are potential sources of strong E or NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range. The lows which produce and NE'ly winds at Bizerte follow an E'ly track S of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at about 35°N, roughly between Sfax and Sousse. NE'ly winds at Bizerte may also be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa.

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE
3. <u>Anchored - outside harbor</u>. Most common in Winter & Spring, uncommon in Summer, possible by Autumn	a. <u>NW'ly winds/waves</u> - Strong (40-50 kt) NW'ly winds reach Bizerte with waves exceeding 10 ft. Normally result when strong mistral event occurs in Gulf of Lion and extends to Tunisia. Primarily occur October through May.	a. Strong winds and waves exceeding 10 impact ships in the anchorage. When wi kt (force 7-8), ships will need to use 109 fm (200 m) of chain to prevent drag Stronger winds may dictate need to move protected waters south of Cape Farina (mi E of Bizerte).

Table 3-1. (Continued)

EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
a. Strong winds and waves exceeding 10 ft will impact ships in the anchorage. When wind is 28-40 kt (force 7-8), ships will need to use at least 109 fm (200 m) of chain to prevent dragging. Stronger winds may dictate need to move to better protected waters south of Cape Farina (about 20 n mi E of Bizerte).	a. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France. This pressure gradient is normally associated with Genoa cyclogenesis. (2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed. (3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia. (4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. A diurnal variation in mistral strength is noted, with over-water velocities strongest during the night. Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface. Another possible cause of strong NW winds at Bizerte is the passage of a N African low NE across the coast of Tunisia towards Sicily. Strong winds are likely W of the NE tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb).

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACT
Most common in Winter & Spring, uncommon in Summer, possible by Autumn	b. E & NE'ly winds/waves - May result from E passage of N African low S of Bizerte. NE winds may be caused by a low pressure system in the Tyrrhenian Sea. Waves in the anchorage are generally limited to about 5 ft.	b. Ships may need to use extra chain to prec dragging anchor. Otherwise little significa effect unless very strong event occurs.

Table 3-1. (Continued)

EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
Ships may need to use extra chain to preclude agging anchor. Otherwise little significant fect unless very strong event occurs.	b. E moving N African lows moving S of the Atlas Mountains prior to their passage S of Bizerte to the Gulf of Gabes are potential sources of strong E or NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range. The lows which produce E and NE'ly winds at Bizerte follow an E'ly track S of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at about 35°N, roughly between Sfax and Sousse. NE'ly winds at Bizerte may also be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa.

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE AC
4. Arriving/ departing. Most common in Winter & Spring, uncommon in Summer, possible by Autumn	a. NW'ly winds/waves - Strong (40-50 kt) NW'ly winds reach Bizerte with waves exceeding 10 ft. Normally result when strong mistral event occurs in Gulf of Lion and extends to Tunisia. Primarily occur October through May.	a. Vessels that need to transit the channel points W of the draw bridge should be aware the bridge cannot be raised when the winds the 35-40 kt range. Therefore, outbound ve must stay in the port and inbound vessels m stay out of the port until the winds abate.

Table 3-1. (Continued)

EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
Vessels that need to transit the channel to points W of the draw bridge should be aware that the bridge cannot be raised when the winds reach the 35-40 kt range. Therefore, outbound vessels must stay in the port and inbound vessels must stay out of the port until the winds abate.	a. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France. This pressure gradient is normally associated with Genoa cyclogenesis. (2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed. (3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia. (4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. A diurnal variation in mistral strength is noted, with over-water velocities strongest during the night. Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface. Another possible cause of strong NW winds at Bizerte is the passage of a N African low NE across the coast of Tunisia towards Sicily. Strong winds are likely W of the NE tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb).

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIC
Most common in Winter & Spring, uncommon in Summer, possible by Autumn	b. E & NE'ly winds/waves - May result from E passage of N African low S of Bizerte. NE winds may be caused by a low pressure system in the Tyrrhenian Sea. Waves in the anchorage are generally limited to about 5 ft.	b. Vessels which need to transit the channel points W of the draw bridge should be aware the bridge cannot be raised when the winds i the 35-40 kt range. Therefore, outbound ves must stay in the port and inbound vessels mu stay out of the port until the winds abate. inbound vessels should be aware that E winds to cause steering problems and force vessels the breakwater.

Table 3-1. (Continued)

EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
b. Vessels which need to transit the channel to points W of the draw bridge should be aware that the bridge cannot be raised when the winds reach the 35-40 kt range. Therefore, outbound vessels must stay in the port and inbound vessels must stay out of the port until the winds abate. Also, inbound vessels should be aware that E winds tend to cause steering problems and force vessels onto the breakwater.	b. E moving N African lows moving S of the Atlas Mountains prior to their passage S of Bizerte to the Gulf of Gabes are potential sources of strong E or NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range. The lows which produce E and NE'ly winds at Bizerte follow an E'ly track S of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at about 35°N, roughly between Sfax and Sousse. NE'ly winds at Bizerte may also be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa.

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE A
5. Small boats. Most common in Winter & Spring, uncommon in Summer, possible by Autumn	a. NW'ly winds/waves - Strong (40-50 kt) NW'ly winds reach Bizerte with waves exceeding 10 ft. Normally result when strong mistral event occurs in Gulf of Lion and extends to Tunisia. Primarily occur October through May.	a. Small boat operation within the confi the Old Port/Outer Port should be only mi affected, but runs to/from the anchorage the harbor would necessarily be curtailed strong event.

Table 3-1. (Continued)

EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
a. Small boat operation within the confines of the Old Port/Outer Port should be only minimally affected, but runs to/from the anchorage outside the harbor would necessarily be curtailed in a strong event.	a. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France. This pressure gradient is normally associated with Genoa cyclogenesis. (2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed. (3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia. (4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. A diurnal variation in mistral strength is noted, with over-water velocities strongest during the night. Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface. Another possible cause of strong NW winds at Bizerte is the passage of a N African low NE across the coast of Tunisia towards Sicily. Strong winds are likely W of the NE tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb).

Table 3-1. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE AC
Most common in Winter & Spring, uncommon in Summer, possible by Autumn	b. E & NE'ly winds/waves - May result from E passage of N African low S of Bizerte. NE winds may be caused by a low pressure system in the Tyrrhenian Sea. Waves in the anchorage are generally limited to about 5 ft.	b. Runs to/from the outer anchorage may ne be curtailed. A NE wind would be roughly p to the orientation of the channel, so smal operations in the channel could be in jeopa a strong NE wind situation.

Table 3-1. (Continued)

EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
b. Runs to/from the outer anchorage may need to be curtailed. A NE wind would be roughly parallel to the orientation of the channel, so small boat operations in the channel could be in jeopardy in a strong NE wind situation.	b. E moving N African lows moving S of the Atlas Mountains prior to their passage S of Bizerte to the Gulf of Gabes are potential sources of strong E or NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range. The lows which produce and NE'ly winds at Bizerte follow an E'ly track S of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at about 35°N, roughly between Sfax and Sousse. NE'ly winds at Bizerte may also be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa.

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PORT VISIT INFORMATION

JANUARY 1990. NOARL Meteorologists R. Fett and Lieutenant M. Evans, U.S. Navy met with Port Director Omar Majdoub, Port Captain Ben Fadhel Sahbene, and Pilots Cherif Mohamed Elhedi and Ben Hassen Hassen to obtain much of the information included in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides some general definitions regarding waves and is extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955).

Definitions

Waves that are being generated by local winds are called "SEA". WAVES that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN-BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period ($f = 1/T$); therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A Beaufort Scale table with related wave effects is shown on the following page.

BEAUFORT SCALE

Beaufort Number	Wind Speed Knots	Wind Speed MPH	Seaman's term	Effects observed at sea	Term and height of Waves in meters
0	Under 1	Under 1	Calm	Sea like mirror.	Calm, glassy, 0
1	1-3	1-3	Light air	Ripples with appearance of scales; no foam crests.	
2	4-6	4-7	Light breeze	Small wavelets; crests of glassy appearance, not breaking	Rippled, less than 0.5
3	7-10	8-12	Gentle breeze	Large wavelets; crests begin to break; scattered whitecaps.	Smooth, 0.5
4	11-16	13-18	Moderate breeze	Small waves, becoming longer; numerous whitecaps.	Slight, 1.0
5	17-21	19-24	Fresh breeze	Moderate waves, taking longer form; many whitecaps; some spray.	Moderate, 1.0-2.5
6	22-27	25-31	Strong breeze	Larger waves forming; whitecaps everywhere; more spray.	Rough, 2.5-4.0
7	28-33	32-38	Moderate gale	Sea heaps up; white foam from breaking waves begins to be blown up in streaks.	Very rough, 4.0-6.0
8	34-40	39-46	Fresh gale	Moderate high waves; edges of crests begin to break; foam is blown in steaks.	
9	41-47	47-54	Strong gale	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.	
10	48-55	55-63	Whole gale	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.	High, 6.0-9.0
11	56-63	64-72	Storm	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.	Very high, 9.0-13.5
12 13 14 15 16 17	64-71 72-80 81-89 90-99 100-108 109-118	73-82 83-92 93-103 104-114 115-125 126-136	Hurricane	Air filled with foam; sea completely white with driving spray; visibility greatly reduced. Winds of force 12 and above very rarely experienced on land; usually accompanied by widespread damage.	Phenomenal, greater than 13.5

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